

BARRIERS TO SUSTAINING ENERGY EFFICIENCY AND ENERGY SECURITY IN DEVELOPING COUNTRIES

JERUSHA JOSEPH & PROFESSOR FREDDIE INAMBAO

Department of Mechanical Engineering, University of KwaZulu-Natal, Durban, South Africa

ABSTRACT

The uptake and investment in renewable and other less carbon intensive energy sources including the impact of energy efficiency have not shown the required consistency to transform our carbon-intensive energy generation to mitigate climate change. This lack of consistency is due to climate change efforts having to work through multiple barriers in various dimensions of our created economic world with its political and social dynamics. Some climate change efforts overcome these barriers and some efforts are not being realised due to their inability to move past the barriers. These barriers exist in greater measure for developing economies of the world than in developed economies largely due to the dynamics of the political, technological and financial dimensions. Understanding the origins of these barriers is necessary to understand the current barriers well enough to find ways to overcome them. This paper investigates the barriers to energy efficiency and energy security in developing countries, contextualising their origins and outlining the required focus to overcome the barriers.

KEYWORDS: *Barriers to Energy Efficiency; Barriers to Energy Security in Developing Countries; Policy and Regulatory Barriers to Energy Efficiency and Energy Security; Technical Barriers to Climate Change in Developing Countries & Financial Barriers to Climate Change*

Received: Aug 23, 2021; **Accepted:** Sep 13, 2021; **Published:** Nov 05, 2021; **Papber Id.:** IJMPERDDEC202111

1. INTRODUCTION

As climate change adaptation moves from theory to practice, barriers may make it difficult for individuals, businesses and governments to plan and implement adaptation actions. Addressing these barriers is critical to advancing climate compatible development. Adaptation refers to actions to prepare for, or reduce the harm from, the effects of climate change. It involves a wide range of measures undertaken by multiple actors and at differential spatial levels, including subnational, national and regional levels. Planned adaptation is important for future economic development, especially for developing countries, where adaptation strategies need to be built into emerging development paths, given the current momentum of rapid growth, investment and urbanisation [1].

Energy management is widely recognised as a primary means to overcome barriers to energy efficiency. Research shows that the adoption of energy management practices in industries may save up to 40 % of the total energy used, half being derived from energy management practices and half from investments in energy-efficient technologies. Energy services is a relatively new term that refers to contractual arrangements that aim to measurably improve energy efficiency. Apart from energy audits, an energy service company (ESCO) can offer financial support in the investments in new technology, as well as additional services, e.g., support in managing the intervention within the plant and providing information about existing opportunities. Energy performance contracting (EPC) and third-party financing (TPF), as well as energy audits, are key means, according to the

European Commission, to improve energy efficiency in the economy. Energy services have been mentioned both in academic literature and in political directives as a tool to overcome many of the barriers to energy efficiency in organisations whose core business is not related to energy. Consulting an ESCO is a way for organisations to out-source energy management [2].

ESCOs help in overcoming informational and financial barriers since an ESCO's core business is energy management, and their services require them to stay well informed about technical and economic energy management solutions. Since ESCOs are specialised in energy savings they have the advantage of economies of scale and making use of their knowledge multiple times, thus reducing the costs for knowledge assimilation per kWh of improved energy efficiency. TPF helps to overcome capital shortages. Energy services are provided in performance-based contracts, which also reduces the risk since the ESCO shares the project risk. However, consulting an external party to manage something as complex as an industrial energy system also implies transaction costs. What an ESCO gains in scale advantage and reduced risk must be compensated for by the extra costs generated from transferring some or all of the responsibility for energy management to an external party. Since transaction costs are not necessarily related to the size of the contract, this results in complex energy services being more profitable in large contracts [2].

A case study on driving forces for improved energy efficiency in the foundry industries in Finland, France, Germany, Italy, Poland, Spain, and Sweden found that in at least 50 out of the 65 investigated foundries, the primary drivers were rising energy prices, cost reductions resulting from lowered energy use, commitment from top management, energy and emission taxes, people with real ambition, a long-term energy strategy, and international [2].

The services that ESCOs offer in most developed countries are not easy to find in developing countries. Even rarer to find is expertise in alternative energy such as natural gas power plants which have about 50 % of the carbon footprint of traditional coal-fired power plants and renewable energy such as solar PV, solar thermal energy, geothermal energy, wind energy, ocean energy, hydro energy, etc. The lack of expertise and familiarity with these technologies form barriers to their adoption. Developing countries face another barrier in the financial dimension in that the necessary capital required to transition towards energy efficient technologies, alternate and renewable energy technologies is not available. The capital funds that most developing countries have are locked in social development such as health infrastructure, education and its platforms, food and the agricultural industry and government efforts are locked into the lowest first cost initiatives.

Traditional fossil fuel energy and its technologies are established market technologies that are mature and thus can be secured at competitive prices. The technology maturity has also allowed the operations and maintenance skills to proliferate, with experience of operating and maintaining the technologies being preserved. This provides a platform that is affordable, reliable and familiar with fossil fuel intensive energy sources, making the transition to cleaner energy sources more difficult. The following sections describe the origin of the barriers that developing countries face in the journey of transitioning towards energy efficiency and energy security, followed by a focus on the specific barriers in the political, technological and financial dimensions and the focus required to overcome these barriers.

2. THE ORIGIN OF ALL BARRIERS TO ENERGY EFFICIENCY AND ENERGY SECURITY IN DEVELOPING COUNTRIES

“The heart of sustainable development and business sustainability requires sustainability in each dimension of economic,

social and environmental factors to merge on common ground and operate in the ‘sustainable’ zone.” [3]. These three dimensions of sustainability work with each other to satisfy human needs (Fig. 1). The social dimension encapsulates the way in which humans relate to each other, the natural environment and the various interactions required for the fulfilment of their needs and wants in the created financial economy. “A social construction is built around serving human needs and wants and these are characterised in Maslow’s hierarchy of needs.” [3]. This social construction is the origin of the regulations, policies, legislation and political frameworks. “Social sustainability can be described as equity in resource distribution, which, from a livelihood perspective, is regarded as the capacity of the human species not only to get access to but also to maintain an adequate and decent livelihood.” [3]. Resource distribution and access is regulated through the economy. “Production is the heart of the economy which is the manufacture of goods and enabling of services. There are four factors that make production possible, i.e. capital, land, labour and entrepreneurship. These factors give the ability to satisfy needs and start the circulation of income (enable trade).” [3]. With time, the created economy, in turn, has an impact on the social dimension as well as the natural environment, making the dimensions represented by Fig. 1 intrinsically dependant on each other. The use of natural environmental resources (environmental dimension) requires building human capability (social dimension) as well as capital accumulation (economic dimension) for the fulfilment of human needs.

“Each country can be seen as having natural resources and skilled personnel which can be used to build their economy. The economic factors in a country include accessibility of natural resources, energy and energy resources, capital accumulation, technological resources, available labour force, transportation and communications, education and training.” [3] Each country is endowed differently in terms of its natural resources and this characteristic has led to the history of colonisation and the use of forced rule over certain countries to get control over their natural endowments and geographical location for trade routes and enabling markets. The political framework that each country in the world finds itself in has been shaped through times of war largely due to the battle for economic security.

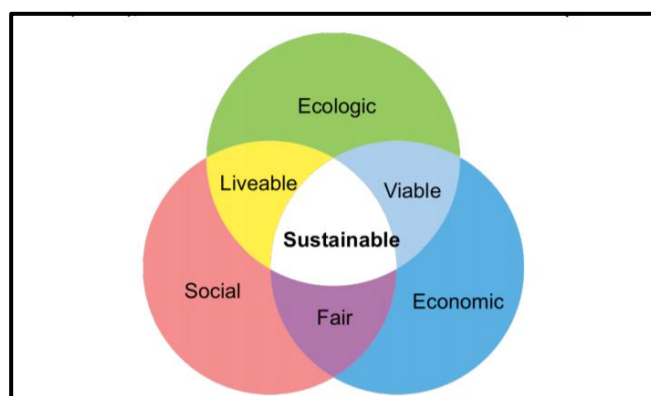


Figure 1: Business Sustainability Mesh [4].

The governments or ruling entities of a country play a key role in shaping the economy, including making choices for trade and investment markets and having in place agreements with other countries for imports and exports which have a knock-on effect resulting in financial investment being made for education and training programmes, manufacturing and other infrastructure, etc. in the line of technologies they wish to promote and proliferate. The government or ruling entities regulate these through various strategies, legislation, policies and frameworks. The barriers that climate change face are based on and related to the economic competition posed by current matured solutions in the commercial market. The overcoming of these barriers to allow for climate change considerations in technology take time depending on the nature of

the existing market as well as the dynamics of the factors supporting it such as the technology lifespan, labour market, price, reliability, etc. Some changes fail in penetrating the market to the intended level or taking over competition as legislation, policies, government strategies and foreign investment protect and support the existing markets and may even directly stop any developments that support climate change mitigation. This is evident in the long reign of Eskom, South Africa's energy service provider which is a monopoly; their investment in renewable energy is largely through invitation to private companies and investors and this limited in installed capacity. When Eskom failed to bring in more capacity to support the country's growing electricity demand, the government adjusted policies to allow certain businesses and domestic households to produce their own renewable energy, only up to a specific installed capacity, limiting the proliferation of renewable energy throughout the country.

This implies that technological changes necessary to mitigate climate change and preserve human life need assistance to overcome market and other dynamics. In the context of technologies and changes necessary for energy efficiency and energy security in the face of climate change, there are unique barriers in developing economies of the world. In developed economies, the need for energy access, the benefits of energy efficiency and in many cases energy security have already been satisfied prior to the dilemma of climate change becoming urgent, thus the change to reduction in carbon emissions will mean taking one step according to Fig. 2. For developing economies where most of the country is yet to be electrified, this means making a leap from a focus on energy access to a focus on reduction in carbon emissions (Fig. 2).

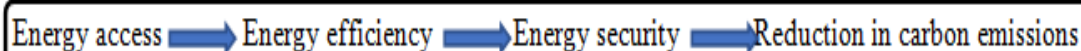


Figure 2: Energy Efficiency and Energy Security Value Chain in the Context of Climate Change.

It may be argued that developed countries will have a harder journey transitioning to reduction in carbon emissions due to their energy generation technology base being already in place and developing countries who largely do not have their energy generation in place will have the opportunity to “leapfrog” into a reduced carbon emissions energy generation base. This may be true from the perspective of infrastructure establishment where existing carbon-intensive energy generators will have to “run their course” to be replaced in developed countries and developing countries will not have to face this problem giving them an advantage to realise low carbon energy generation sooner. What developed economies have gained through the journey of energy efficiency and energy security places them in a better financial and political position having developed human resource capacity to realise the transition to low-carbon energy generation. Developing energy security before the climate change dilemma emerged meant diversification of the energy generation base, which developed countries have managed to do effectively, meaning that they have gained the experience required for incorporating multiple energy sources.

The uniqueness of barriers faced by developing countries are due to the journey that they must take to achieve both energy efficiency and energy security in reducing carbon emissions while satisfying energy access. The barriers associated with achieving energy efficiency and energy security in developing countries are presented in this paper and classified according to the three main categories of barriers (Fig. 3).

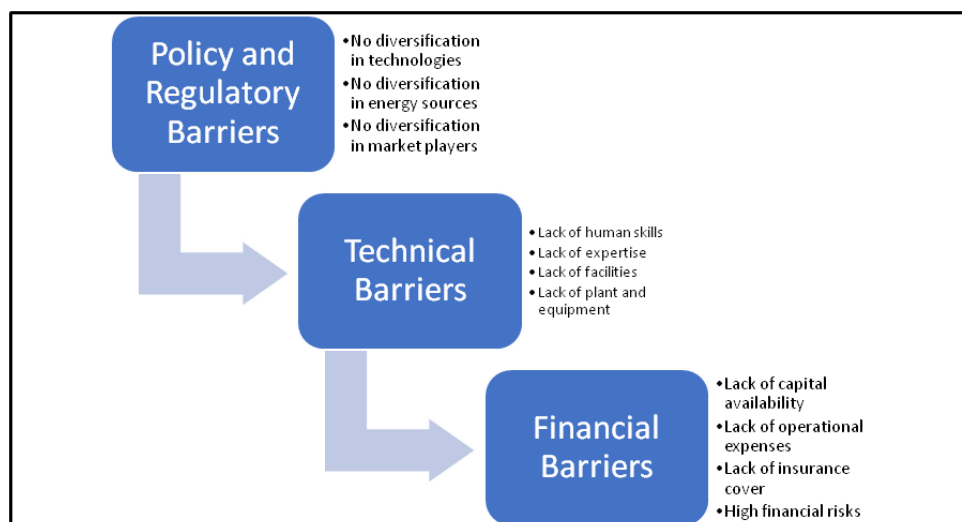


Figure 3: Categories of Barriers to Energy Efficiency and Energy Security.

Most of the barriers originate from the role of the government to ensure safe and good living conditions for citizens using regulation where “Policy and Regulatory Barriers” will be faced, stimulation of technology changes where “Technical Barriers” are faced, and circulation of money where “Financial Barriers” are faced.

3. POLICY AND REGULATORY BARRIERS

Consistent and accessible information and the capacity to apply it is essential for effective adaptation [5]. Information barriers are associated with the development, useability of and access to information, data and knowledge [6]. Access to reliable and usable information is key to its integration into policy and regulations. Governance and policy barriers are associated with policy, processes and their level of integration and collaboration on cross-cutting and multi-scaled adaptation planning [6]. Organisational and institutional barriers are within the structures, processes and behaviours of society and organisations that limit the agility and viability of adaptation plans and implementation success [6]. Psychological factors influence our ability to act on information about climate change, including our perception of how urgent adaptation is [5]. Psychological and social barriers are associated with cognitive ability, denial, cultural and behaviour norms of individuals and collective organisations that limit awareness or willingness to act on adaptation measures [6].

Our knowledge of human impacts and their effects on the climate of our planet is progressive which can serve to undermine the information already uncovered. Many times in the history of scientific research, the understanding seemingly established by certain information could be changed by uncovering new information. Added to this is the effects of climate change being gradual relative to the everyday poverty, hunger, economic challenges and crime we experience on a daily basis, therefore the challenge of climate change is not perceived as urgent enough for governments to expend effort and investment into climate change mitigation. Even though the number of papers published on climate change have been increasing since the turn of the century (Fig. 4), awareness of these issues still needs to penetrate into the social, economic and built environment (Fig. 5). Only 5 % of these papers relate to energy, with most relating to environmental science (25 %) followed by earth and planetary science (22 %), agricultural and biological sciences (16 %), social science (8 %), engineering (5 %), and economics (2 %).

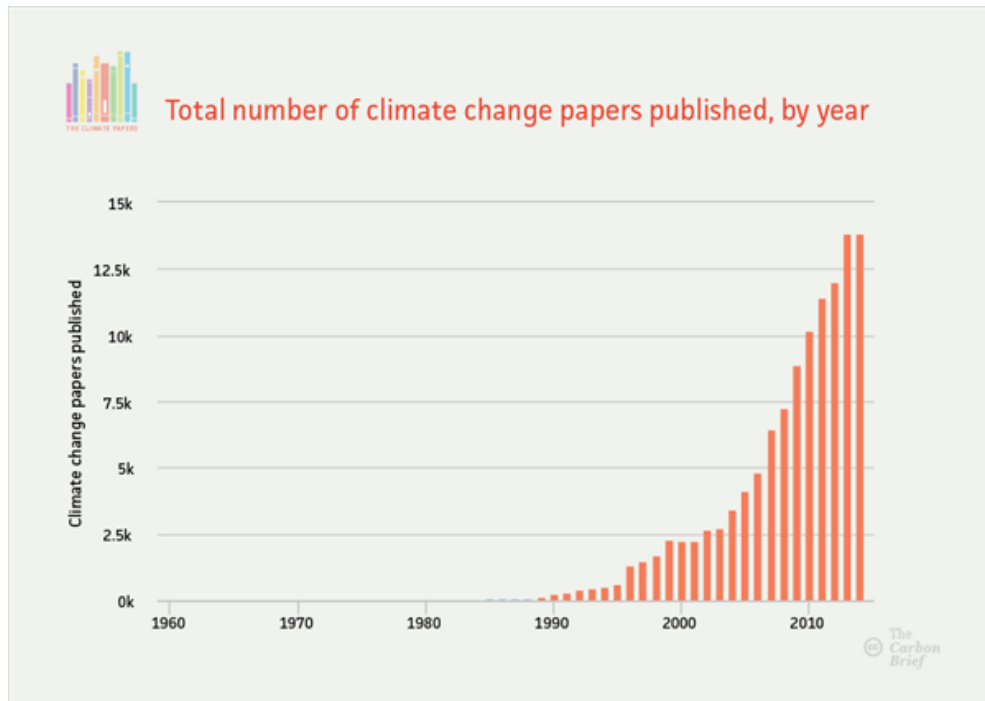


Figure 4: Total Number of Climate Change Papers Published, by Year [7].

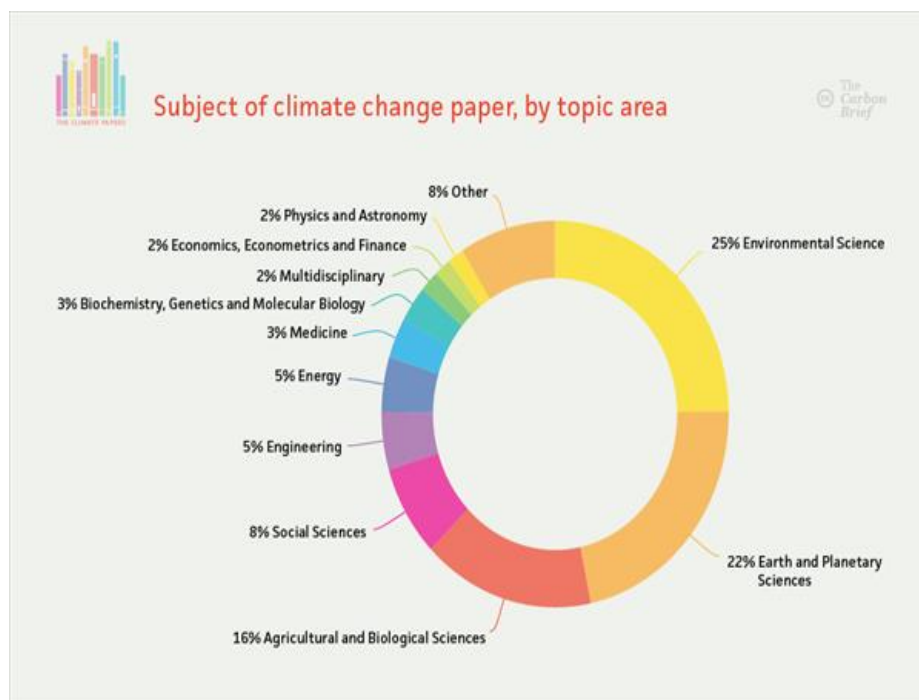


Figure 5: Subject of Climate Change Papers, by Topic Area [7].

When there is an urgency about the threat of climate change, like the urgency that changed the lives of all people of the world when the COVID-19 pandemic hit the world towards the end of 2019, then sustained efforts are seen. Only when people in government are convinced that climate change is a real threat will policies and action be implemented for its mitigation. Government policies and regulations usually protect a country's interests and are meant to influence and control economic activity in a specific way, and influence social perceptions and behaviour in a way that protects people

from exploitation and keep them from harm. Policy failures occur when regulations or policies create barriers to effective adaptation which can arise when there are conflicting or competing policy objectives, or a lack of clarity in the objectives and there are no appropriate mechanisms for addressing the problem [1]. Policy failures also occur when regulation creates market distortions which incentivise organisations or individuals to under- or over-adapt [1]. These issues all prevent the development of efficient policy solutions [1].

Even if the risks posed by climate change and options to adapt are understood, markets may not always generate the right signals for individuals and businesses to prepare for climate change [5]. For example, governments often act as insurers of last resort for the adaptation choices made by others, creating moral hazard which reduces incentives for self-preparedness [5]. While some policies and regulations may be in the favour of most citizens and serve a country well, they must be revised regularly to ensure that they are still relevant to the people they serve. Even this relevance, left open to interpretation, can mean that continuing in current policies and regulations are still in the interests of people. Policies and regulations should thus consider what is best for human life and its preservation not just in the short term, but also in the medium and long term.

In many countries, power utilities still hold a monopoly on electricity production and distribution and in the absence of a legal framework, independent power producers may not be able to invest in renewable energy facilities and sell power to the utility or to third parties under so-called “power purchase agreements” [8]. South Africa specifically has policies and regulations in place that keep the service provider Eskom as a monopoly in the electricity market. Eskom still does not have a structured and sustainable integrated plan to transition their aged coal-fired power stations towards alternative less carbon intensive energy sources. State power utilities may only negotiate power purchase agreements on an individual ad-hoc basis, making it difficult for project developers to plan and finance projects on the basis of known and consistent rules [8]. This is a very short term view of power generation technology that lasts at least 25 years relative to the time available to reduce carbon emissions mitigating climate change.

Policies and regulations that do not support climate change mitigation usually result in a lack of diversification of technologies, energy sources and market players (Fig. 3). There is a culture within organisations that also contribute to and strengthen the lack of diversity of energy production technologies. In developing countries, organisations choose low first cost and stick to familiar technologies that seem to bring in increased profit at continuous relative decreased cost due to economies of scale.

As adaptation is a fairly new theme in policy-making, the existing structure and/or regulatory policy framework may be poorly aligned to adaptation objectives. For this reason, policy issues are a particular challenge. Urban development objectives may not take into account the vulnerability of people and assets to climatic risks. Governance failures occur when there is ineffective institutional decision-making and/or policy implementation which constrains adaptation, creates barriers and/or slows planning and delivery. In developing countries, governance failures are a particular problem, forming an impediment to fiscal planning and access to finance [1].

“Behavioural barriers arise for a variety of reasons, which are often quite complex. Indeed, social, ethical, religious and cultural considerations will shape individual and societal norms and rules; these include risk perception and the management and allocation of resources. These same issues also affect the underlying importance that groups may place on scientific findings versus indigenous knowledge, or the value they give to different places and traditions. These factors may therefore constrain efforts to reduce climate risk or undermine preferences for efficient and effective

adaptation. Adaptation is associated with an additional challenge since people generally find it difficult to make trade-offs across time and between options with uncertain benefits. This includes ‘time inconsistency’ between the short-and long-term decisions. It is also clear that when people make choices, their current reference point matters; notably, people dislike losing goods more than they like gaining them (this is termed ‘loss aversion’). At the organisational level, this also makes it difficult to implement reforms and policy changes that transfer resources from one interested group to another, even if it will lead to overall societal gains” [1].

Two of the institutional barriers faced by the United Nations Industrial Development Organization’s (UNIDO’s) Industrial Energy Efficiency (IEE) project is the mindset of managers whose thinking is that a focus on energy efficiency costs money and time, and the mindset of plant managers who, even though agreeing with energy efficiency, will not give effect to plant adjustments for more efficient running for fear of losing their jobs because of the many years they have run the plant inefficiently. Some managers who initially agree on climate change mitigation may turn their efforts to fight it purely because it does not bring the desired acknowledgement or advantage to themselves or their allies. These are complex psychological barriers that play out in institutional environments at all levels which suffocate efforts towards climate change mitigation.

Resource barriers relate to implementing adaptation due to the development or deployment of financial, technological, human or informational resources [6]. If South Africa has to change all its policies tomorrow, with all the finances and infrastructure in place to implement renewable and alternative energy, it still does not have the technical capacity in terms of human skills and expertise in the magnitude needed to design, operate and maintain alternative and renewable energy technologies.

4. TECHNICAL BARRIERS

Technical barriers to realising energy efficiency and energy security in developing countries start with settling for a few selected matured technologies (Fig. 6) and benefitting from their competitively low cost. While this is important for mass development, it can be a limiting factor for exploiting the market for developing technologies that are important for progress. It makes for a rigid structure of sticking to well-known commercially available technologies mostly with manufacturing and designs being owned by parties in foreign countries and or funded by foreign investment. This forms a ‘safe zone’ in established and matured markets and any new technologies create anxiety that comes with unfamiliarity. This practice has also created a culture of separation and disconnect between the academic and research institutions and technology development.

Education and training are usually aligned to support the endeavours of a country and its commercial market demand. Educational programmes and training are usually based on a market pull. In most cases where the cost of technologies means everything to an investment that looks for lowest first costs, the market pull will always win over any attempt to establish different technologies. However, when looking at climate change mitigation and renewable energy technologies, most commonly this needs to be done through a technology push, aided with policies and legislation to support it. The “technology push” approach attempts to interest the market in new products based on new solutions. The technology cycle can be seen in Fig. 7.

Estimate Rating	Description
Mature	Significant commercial experience (several operating commercial units)
Commercial	Nascent commercial experience
Demonstration	Concept verified by integrated demonstration unit
Pilot	Concept verified by small pilot facility
Laboratory	Concept verified by laboratory studies and initial hardware development
Idea	No system hardware development

Figure 6: Technology Development Description [9].

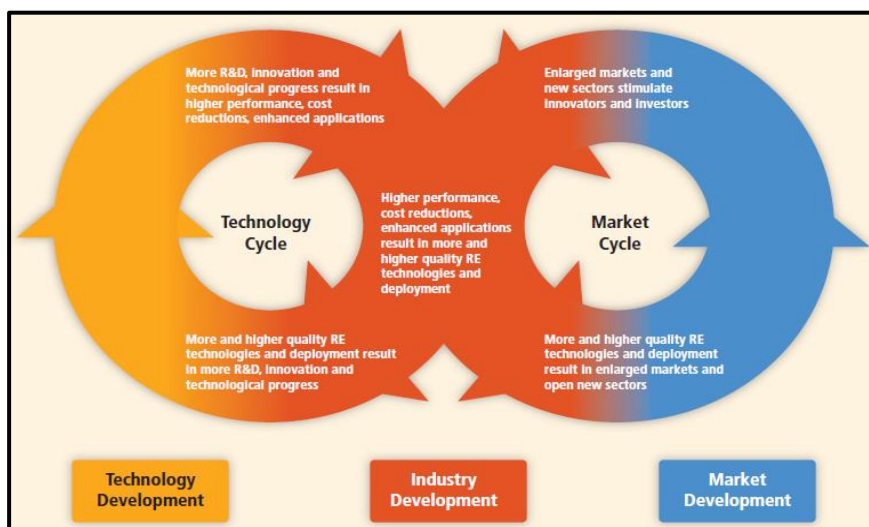


Figure 7: The Mutually Reinforcing Cycles of Technology Development and Market Deployment Drive down Technology costs [10].

Cycles of technology development, industry development and market development usually occur in developed countries first. This means that the learnings and skills associated with the cycles are also mainly in developed countries. Thus, market exploitation of the technologies, manufacturing plants and equipment, their operations and maintenance markets are located in developed countries. The developing countries buy technologies and services from developed countries, and it could be decades until a plant is established in a developing country, and even then, the designs and patents will be held within the developed countries. Therefore, developing countries will always lag developed countries in the technology cycle.

It takes even longer for skills and expertise to transfer to the local communities in developing countries. Most educational programmes and training revolve around the learnings and unique experiences of developed countries where the technologies were established. Thus many technologies when introduced into another country have to live for a few life cycles before their designs capture local design modifications for suitability to the operating environment. This knowledge is also vested in the developed countries research and development experience such that they know more about the operating conditions of a developing country than the developing country knows about its own surroundings. Research and development, tertiary education institutions and the commercial markets are closely linked and have a relationship allowing them to grow their technology and plant base, while this is notably absent in many developing countries.

The disconnect in developing countries between the tertiary education sector and commercial markets undervalues research and development. An investor (including local investors) would choose to invest in something developed by or in development in a developed country rather than to build from scratch their own technology in their own country. This undermining of local talent and regard for tertiary education is deep, to the extent that, for simple things like energy efficiency practices of established technologies, it often takes foreign programmes with foreign consultants to kick-start an industrial energy efficiency programme (UNIDO's Industrial Energy Efficiency Project), while these could have easily been identified with current established engineering programmes and degrees which South African graduates possess.

The lack of capturing institutional knowledge and learnings on existing engineering systems also contributes to the technology barrier to achieving energy efficiency and energy security in developing countries. When electricity is needed, efforts to investigate various energy sources available and energy generation technologies and performing a technical assessment to decide which technology option is best for the site, is a rare occurrence in developing countries. The practice is to have a default energy source and energy generation technology for supplying energy needs.

It is very important to note that every technology type is based on basic engineering and scientific principles which, if applied, can lead to locally designed technologies suited to the operating environment where skills are locally grown. For new technologies to emerge, sound investigations need to be conducted, and for local people to be committed to all phases of the project to ensure that skills and knowledge transfer is facilitated. This may require capital outlay for investment into small scale test projects and pilot plants, field investigations and design cost for scale up projects.

5. FINANCIAL BARRIERS

Certain developing countries do not have the finance or resources to spend whether it is for food security or for climate change mitigation. However, there are developing countries that have finances, but these are tied up in other commitments and priorities. The financial barriers faced by developing countries are two-fold, in that there is a limitation of funds and there is an inefficient allocation of funds which neglects facilitation of innovation, proper investigation and consideration of the bigger picture.

A notable pattern is that developing countries tend to "follow" developed countries when it comes to policy, legislation, commercial markets and technology. This is good in the context of avoiding "reinvention of the wheel", avoiding risk and costly development investment, but also means that developing countries lose out on mobilising profits associated with new technologies. This thinking has led to and widens the gap between the wealth of developed countries and developing countries. Many raw materials exported to developed countries (from developing countries) find financial returns in processed goods from sales to developing countries.

Economic activity is founded upon demand for goods or services. Developing countries find themselves in challenging positions where satisfying their countries' demand for goods and services relies heavily on developed countries. Figure 8 shows the imported and local content for various technologies, materials and labour.

Technology	Imported	Local	Materials (Local)	Labor (Local)
PC	35%	65%	50%	50%
Integrated Gasification Combined Cycle	35%	65%	60%	40%
FBC	35%	65%	50%	50%
Nuclear	35%	65%	60%	40%
CCGT	35%	65%	60%	40%
OCGT	35%	65%	85%	15%
Wind	70%	30%	75%	25%
Solar Thermal	50%	50%	45%	55%
Solar PV	70%	30%	60%	40%
Biomass	35%	65%	50%	50%

Figure 8: Local and Imported Content for Technologies in South Africa [9].

Renewable energy is still significantly reliant on imported content, yet it is needed not just for climate change mitigation, but for additional capacity to satisfy South Africa's growing energy demand. It is key that investment is made in renewable and alternative clean energy education, training, manufacturing, research and development. Also important is that the true cost of coal fired power station electricity generation which includes the mining of coal and its logistics should be used when comparing it to renewable and alternative energy sources electricity generation.

There is a culture in developing countries, especially in state-owned and controlled entities where sound economic analysis that includes quantifiable expenses and benefits over the economic lifespan of the targeted technology is not considered nor are they traded off against a variety of options.

Ensuring that economic models are attempted for each investment is crucial to making the most efficient and effective investment decision. Many times, perceptions and opinions are followed rather than sound scientific investigation and financial modelling providing the best solution.

6. THE FOCUS REQUIRED TO OVERCOME THE BARRIERS

The focus to overcome barriers to energy efficiency and energy security in developing countries may be different based on specific challenges experienced by the country and its institutions. Fig. 9 shows the key characteristics of the five shared socio-economic pathways for climate change adaptation and mitigation. From the characteristics given, many countries can be associated with these scenarios. The developing countries are usually in the bottom right hand corner (SSP4) while the developed economies (SSP5) are in the top left hand corner with transitioning economies (SSP2) in the middle. The desired pathway is to be in is SSP1, at the bottom left hand corner.

Socio-Economic Challenges to Mitigation	Socio-Economic Challenges to Adaptation		
	Low	Medium	High
High	SSP5: Fossil-fuelled development <ul style="list-style-type: none"> • low population • very high economic growth per capita • high human development • high technological progress • ample fossil fuel resources • very resource intensive lifestyles • high energy and food demand per capita • economic convergence and global cooperation 		SSP3: Regional rivalry <ul style="list-style-type: none"> • high population • low economic growth per capita • low human development • low technological progress • resource-intensive lifestyles • resource-constrained energy and food demand per capita • focus on regional food and energy security • regionalization and lack of global cooperation
Medium		SSP2: Middle of the road <ul style="list-style-type: none"> • medium population • medium and uneven economic growth • medium and uneven human development • medium and uneven technological progress • resource-intensive lifestyles • medium and uneven energy and food demand per capita • limited global cooperation and economic convergence 	
Low	SSP1: Sustainable development <ul style="list-style-type: none"> • low population • high economic growth per capita • high human development • high technological progress • environmentally oriented technological and behavioural change • resource-efficient lifestyles • low energy and food demand per capita • economic convergence and global cooperation 		SSP4: Inequality <ul style="list-style-type: none"> • Medium to high population • Unequal low to medium economic growth per capita • Unequal low to medium human development • unequal technological progress: high in globalized high-tech sectors, slow in domestic sectors • unequal lifestyles and energy /food consumption: resource intensity depending on income • Globally connected elite, disconnected domestic work forces

Figure 9: Key Characteristics of the Five Shared Socio-Economic Pathways [11].

The desired pathway (SSP1) for sustainable development highlights technological progress, economic growth and human development as key characteristics, and low energy demand and resource-efficient lifestyles are included as ingredients. This implies a complete shift of lifestyle, thinking, and creation of wealth that is in harmony with the natural environment. If one looks at the current renewable energy policies and barriers (Table 1), it can be seen that much work has been identified and done to remove barriers to renewable energy adoption. Nonetheless, this does not give an indication of the creation of an economy that is in harmony with the natural environment.

Table 1: Summary of Renewable Energy Policies and Barriers [12]

	Policies	Description	Key Barriers Addressed
Renewable energy promotion policies	Price-setting and quantity forcing policies	Mandates prices to be paid for renewable energy, or requires a fixed amount or share of generation to be renewable	High costs, unfavourable power pricing rules, perceived risks
	Cost reduction policies	Reduces investment costs through subsidies, rebates, tax relief, loans, and grants	High costs, perceived risks
	Public investments and market facilitation activities	Provides public funds for direct investments or for guarantees, information, training, etc. to facilitate investments	Transaction costs, perceived risks, lack of access to credit, information, and skills
	Power grid access policies	Gives renewable energy equal or favourable treatment for access to power grids and transmission systems	Independent power producer frameworks, transmission access, inter-connection requirements
Transport biofuels policies	Biofuels mandates	Mandates specific shares of transport fuel consumption from biofuels	Lack of fuel production or delivery infrastructure
	Biofuel tax policies	Provides tax relief for biofuels	High costs

Emissions reduction policies	Renewable energy set-asides	Allocates, or sets aside, a percentage of mandated environmental emissions reductions to be met by renewable energy	Environmental externalities
	Emissions cap and trade policies	Allows renewables to receive monetary credit for local pollutant emissions reduction	Environmental externalities
	Greenhouse gas mitigation policies	Allows renewables to receive monetary credit for greenhouse-gas emissions reduction	Environmental externalities
Power sector restructuring policies	Competitive wholesale power markets	Allows competition in supplying wholesale generation to the utility network and eliminates wholesale pricing restrictions	May heighten barriers of high costs, lack of fuel price risk assessment, unfavourable power pricing rules
	Self-generation by end-users	Allows end-users to generate their own electricity and either sell surplus power back to the grid or partly offset purchased power	May reduce barrier of interconnection requirements, but heighten barriers of high costs, lack of fuel price risk assessment
	Privatised and/or commercialisation of utilities	Changes government-owned and operated utilities into private or commercial entities	May reduce barrier of subsidies, but heighten barriers of high capital costs and perceived risks
	Unbundling of generation, transmission and distribution	Eliminates monopolies so that separate entities provide generation, transmission, and distribution	May provide greater incentives to self-generate, including with renewable energy
	Competitive retail power markets	Provides competition at the retail level for power sales, including “green power” sales	May reduce barriers of high costs, lack of information, transaction costs
Distributed generation policies	Net metering	Values renewable energy production at the point of end-use and allow utility networks to provide “energy storage” for small users	Unfavourable power pricing rules
	Real-time pricing	Values renewable energy production at the actual cost of avoided fossil fuel generation at any given time of the day	Unfavourable power pricing rules
	Capacity credit	Provides credit for the value of standing renewable energy capacity, not just energy production	Unfavourable power pricing rules
	Interconnection regulations	Creates consistent and transparent rules, norms, and standards for interconnection	Interconnection requirements, transaction costs
Rural electrification policies	Rural electrification policy and energy service concessions	Makes renewable energy part of rural electrification policy and planning and creates regulated businesses to serve rural customers	Subsidies for competing fuels, lack of skills and information, high costs, lack of access to credit
	Rural business development and microcredit	Supports private entrepreneurs to provide renewable energy products and services to end-users and offer consumer credit for purchases	Lack of skills, lack of access to credit
	Comparative line extension analyses	Analyses the relative costs of renewable energy with conventional fuels and power delivery	Subsidies for competing fuels, lack of information

The focus required to overcome the barriers starts with the acknowledgement of the need to consider climate change mitigation in all commercial activities. Following this, it is necessary to identify the benefits that climate change

mitigation can offer to developing countries who need to exploit the market benefits of new technologies, designs, manufacturing and commercialisation.

Following this, a clear strategy that will allow proliferation of climate change mitigation into the country must be formulated, workshopped and supported by all stakeholders affected and involved. Input should be captured and taken into consideration before a final strategy is approved and concluded for implementation. The strategy must be reasonable, support the needs of the people, and its achievability must be measured.

Policies and regulations should be well structured and coordinated to ensure that they do not conflict with each other. Neglecting to promulgate policies and regulations that support climate change is as much of a barrier as is leaving in place policies that restrict the technology proliferation that support renewable energy. Ensuring that policies and regulations are put in place as a result of a clear, strong and supported strategy for climate change mitigation is key to sustaining energy efficiency and energy security in developing countries. The economy, education, social aspects and political aspects are deeply linked (Figure 10). Making climate change adaptation a source of wealth generation will gain momentum and has the potential to solve many inequality challenges, poverty and other socio-economic challenges faced by a developing country. This will also serve to change the thinking and behaviour of the citizens when they see the potential that climate change mitigation offers.

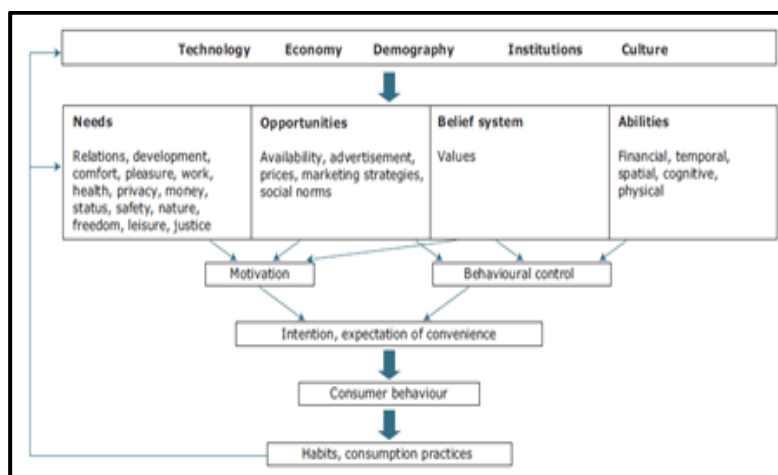


Figure 10: Main Factors Influencing Consumer Behaviour and Emergence of Consumption Practices [13].

Designing the future economy to exploit the market and financial value while capacitating the local workforce will go a long way to closing the inequality gap faced by many developing countries. Planned adaptation can consider future climate risks in locating and designing infrastructure, urban and rural land-use planning, and in managing ecosystem resources such as water and natural systems [1]. In all these cases, investment decisions made today have long lifetimes (5 to 40 years) and will be exposed to climate change in the future, thus the absence of early action may lock in future risks [1]. There is therefore an opportunity to make these early investment decisions ‘climate-smart’ by considering future risks now and looking at early adaptation options [1].

The focus of overcoming the barriers to energy efficiency and energy security in developing countries should be (figure 11):

- To formulate a strategy that will mitigate climate change with continuous updates as per the progress and context

of the implementation

- To integrate energy efficiency and alternative energy sources into social, economic and political agendas and facilitate implementation
- To create policies, regulations, incentives and restrictions appropriately as well as align existing regulations and policies such that they support and facilitate energy efficiency and energy security into the country at all levels
- To use sound economic principles for evaluations and investigations that inform real costing of energy from the different power generation sources and allocate raw materials, land, finances and other resources accordingly to realise a new energy mix that is economically and environmentally sustainable
- To capacitate the citizens for the design, manufacturing, installation, operation and maintenance of new energy generation technologies and sound energy management principles

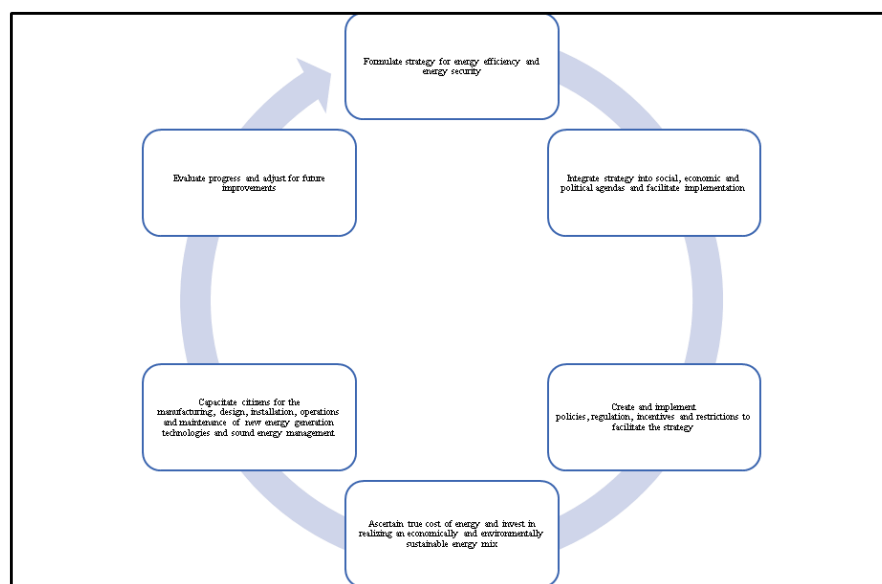


Figure 11: Focus Required to Overcome Barriers Related to Energy Efficiency and Energy Security in Developing Countries.

Constant evaluation of progress as well as consideration of the social and economic context of the strategy implementation, including re-alignment when needed, will ensure that climate change adaptation is relevant to the challenges faced by developing countries. Using climate change adaptation as a means and vehicle to alleviate poverty, create wealth through new markets and capacitate the citizens for increased local labour and monetisation, will serve to overcome barriers to energy efficiency and energy security while meeting socio-economic and political goals.

7. CONCLUSIONS

This paper presented the origin of barriers to energy efficiency and energy security faced by developing countries as well as analysed the political, technological and financial barriers faced. The focus required to overcome these barriers is to have a strategy to mitigate climate change and achieve implementation through integration of the strategy in social, economic and political agendas as a vehicle to achieve the developing country's focus on socio-economic and political interests. In this way, climate change mitigation will be sustained due to the benefits they provide which fulfil a developing

country's key focus areas.

REFERENCES

1. Cimato, F., Watkiss, P., "Overcoming the barriers to climate change adaptation", *Future Climate for Africa*, May 2018. Retrieved from https://media.africaportal.org/documents/fcfa_gcap_economics-guide.pdf, accessed 17/08/2021.
2. Thollander, P., Backland, S., Trianni, A., Cagno, E., "Beyond barriers - A case study on driving forces for improved energy efficiency in the foundry industries in Finland, France, Germany, Italy, Poland, Spain, and Sweden", *Applied Energy*, (111), 2013.
3. Joseph, J., Inambao, F.L., "Sustainability: The big challenge" *International Journal of Engineering Research and Technology (IJERT)*, Vol 13, Number 11, 2020, pp. 3080-3098.
4. Arpin, M.I., "Circular economy: A critical literature review of concepts", *International Reference Centre for the Life Cycle of Products, Processes and Services*, August 2015.
5. Australian government Department of Climate Change and Energy Efficiency, "Barriers to effective climate change adaptation", 23 December 2011. Retrieved from <https://www.environment.gov.au/system/files/resources/c8e1fa00-3d14-4e3b-98a4-b5b338700042/files/barrierstoadaptation.pdf>, accessed 17/08/2021.
6. Mackay, S., Hennessey, N., Mackey, B., "Barriers to the implementation of climate change adaptation plans and action: Considerations for regional Victoria", Griffith University, Brisbane, 2019. Retrieved from https://www.climatechange.vic.gov.au/data/assets/pdf_file/0038/489476/Policy-Brief-1-Barriers-to-the-implementation-of-climate-change-adaptation-plans-and-action.pdf, accessed 17/08/2021.
7. <https://www.carbonbrief.org/analysis-the-most-cited-climate-change-papers>, accessed 19/08/2021
8. Beck, F., Martinot, E., "Renewable energy policies and barriers", *Encyclopaedia of Energy*, Volume 5, 2004, pp 365-383. Retrieved from http://www.martinot.info/Beck_Martinot_AP.pdf, accessed 18/08/2021.
9. Lyon, C., "Power generation technology data for integrated resource plan of South Africa", Technical Update by Electric Power Research Institute (EPRI) prepared for Department of Energy South Africa, April 2017.
10. Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Seyboth, K., Matschoss, P., Kadner, S., Zwickel, T., Eickemeier, P., Hansen, G., Schlömer, S., von Stechow, C., "Renewable energy sources and climate change mitigation", *Special Report of the Intergovernmental Panel on Climate Change*, Cambridge: Cambridge University Press, 2011.
11. Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield, "Global warming of 1.5°C. An IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty", *Intergovernmental Panel on Climate Change*, 2018. Retrieved from https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_High_Res.pdf, accessed 04/06/2021.
12. Beck, F., Martinot, E., "Renewable energy policies and barriers", *Encyclopaedia of Energy*, Volume 5, 2004, pp 365-383. Retrieved from http://www.martinot.info/Beck_Martinot_AP.pdf, accessed 18/08/2021.
13. European Environment Agency, "Achieving energy efficiency through behaviour change: what does it take?", *EEA Technical report*, 2013.

14. Aderonmu, P. A., et al. "Sustainability Parameters in Knowledge Construction: Energy Efficiency Issues of Architectural Design Studio Space." *International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD)* 4.6 (2014): 11-18.
15. Joshi, Krishna. "Application of Energy Concepts for Green Buildings." *International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD) ISSN (P)* (2016): 2249-6866.
16. Usikalu, M. R., Anuoluwapo H. Shittu, and Leke N. Obafemi. "Construction of an intelligent and efficient light control system." *International Journal of Mechanical and Production Engineering Research and Development* 8.4 (2018): 1025-1034.
17. Premkumar, M., et al. "Design, analysis and fabrication of solar pv powered bldc hub motor driven electric car." *Inter. J. Mecha. Produc. Engi. Res. Develop* 8.1 (2018): 1255-1270.

